A PEDAGOGIC INFORMATION SYSTEM (APIS) IN A WEB-BASED STATISTICS CLASSROOM

Socrates G. Boussios

Submitted in partial fulfillment of the requirement for
the degree of Doctor of Philosophy
Under the Executive Committee of the Graduate School of
Arts and Sciences

COLUMBIA UNIVERSITY

2016

ABSTRACT

A PEDAGOGIC INFORMATION SYSTEM (APIS) IN A WEB-BASED STATISTICS CLASSROOM

Socrates G. Boussios

This study investigated the potential application of web-based pedagogy for teachers of elementary statistics, using *A Pedagogical Information System* (APIS), in order to explore ways in which teachers can enhance instruction via technology in the classroom. This information system would provide new opportunities for practical teacher education, given that the literature on statistics pedagogy and web-based teaching and learning is sparse.

The purpose of the study was to examine issues of efficacy, efficiency, and effectiveness of the use of Internet websites in the instruction of introductory statistics at the college level. The design of the study was qualitative and used a phenomenological interpretive method. The participants in this study were four instructors of introductory statistics courses at the undergraduate level of higher education in a northeastern state in the United States. They were interviewed individually for approximately 60 minutes in a semi-structured format in which they discussed their experiences and perceptions about using Internet sources for instruction of students in Introductory Statistics.

The results of the study indicated that teachers welcomed incorporating technology into their classrooms. Participants found that having students with different learning styles, allocating time to deal with details, and having difficulty managing the interplay between topics as being

key problems that could arise in the organization of a web-based introduction to an elementary statistics course. Although all participants agreed that there is a lack of uniformity among statistical topics, most wanted to emphasize descriptive statistics, distributions, probability, inference, confidence intervals, and regression. They acknowledged that web-based learning would radically alter student and teacher roles, so that the teacher would become a mentor and students would become active learners. Instruction would be geared more to practical applications than to theory. Instructors would have to make decisions about how much web-based information they would use and would have to become knowledgeable about web content.

TABLE OF CONTENTS

LIST OF TABLES

ACKNOWLEDGEMENTS

It has been a challenging yet rewarding journey. I would never have completed this dissertation without the guidance and support of my family and friends.

Throughout my years at Teachers College, I have received a great deal of guidance and support from a great number of people. I would like to thank my advisor Dr. Bruce Vogeli for believing in me and encouraging me to pursue my goals. His expertise and wisdom kept me motivated. I would especially like to thank Dr. J. Philip Smith. He provided guidance, support and always believed in me.

For their willingness to serve on my committee, I want to thank Professors Dr. Patrick Gallagher, Dr. Young-Sun Lee, and Dr. Henry Pollak.

To my friends John, Shaun and Allen. Your guidance and support throughout this process was priceless. I will always remember our conversations which encouraged me to continue and to keep faith.

To my parents, Mary and Gregory Boussios. You taught me that with hard work, I can accomplish everything. As I look back on my life, I am constantly reminded of all the love and care you have provided me.

To my wife, Vasiliki Boussios, for being by my side, having confidence in me and encouraging me to accomplish my goals. Without your love and support throughout the years this milestone would not have been achievable. You along with our son Gregory made me focus on the objective and enjoy the journey.

DEDICATION

To my parents, who made me who I am; my wife, who brings out the very best in me; and my son, who gave me the motivation and belief that anything is possible; without them, I could not have done any of this. For that, and so much more, I am eternally grateful.

CHAPTER I

INTRODUCTION

Need for the Study

One of the major weaknesses in education is the difficulty connecting current research and cutting-edge technology to classroom practice. This is especially true for science and mathematics instruction in the United States. While the United States boasts of high achievements in technology, our classrooms do not prepare students adequately for the advanced level of mathematics and scientific competency that many jobs require (Rothkopf, 2009, p. 3; PISA, 2004). Achievement scores are low, and our most talented students are not inspired to continue their education within highly coveted fields. Teachers continue to use older pedagogies based on textbook-only instruction and do not incorporate the expanding and current applications and resources available widely and for free on the Internet. (p. 4). Further, teachers struggle to understand how to apply interactive and web-based approaches to learning in the classroom. This study will investigate the application of web-based pedagogy for teachers of elementary statistics, using *A Pedagogical Information System* (or APIS), originally designed by Dr. Ernst Rothkopf, Professor Emeritus of Columbia Teachers College, in order to explore ways that teachers can enhance instruction via technology in the classroom.

Challenges in the classroom

One of the challenges that continuously emerges in statistics pedagogy throughout the United States is the difficulty of teaching for proficiency and not merely for understanding. According to Kader and Perry (2002), mathematics educators across the country are locked into curricular standards (such as those established by the National Council of Teachers of Mathematics' (NCTM) *Curriculum and Evaluation Standards for School Mathematics* (1989)) that have emphasized conceptual learning over practical application. According to Ma (1999), teacher preparation must link mathematics with the study of how to teach it:

> If teachers are expected to teach probability and statistics for understanding and to become advocates of change, they must become constructive learners and experience learning probability and statistics through a process similar to that of their students. Through such experiences, teachers come to realize that active exploration of statistical concepts provides the necessary structures for building understanding. (viz. Kader and Perry, 2002, p. 1)

This critique of the system unfortunately does not account for the demands of teacher college programs and the pedagogical restraints of time-limited teachers who must emphasize standardized content/testing and not qualitative student learning. The resulting gap between pedagogy and practice is where technology fits in.

Despite the fact that many online resources for learning have developed over the last decade, a significant gap between technology and pedagogy persists. Teachers are still trained primarily to use textbook-only resources since many schools with low budgets do not require students to purchase a computer. School computer laboratories are not fully equipped to handle the needs of mathematics or science courses and the demands of online instruction (Wallace, 2004, p. 448). Additionally, teachers are overwhelmed with the number of resources and are left on their own to figure out how to incorporate these resources into their pre-existing pedagogy (p. 448).

Technology and Web-Based Learning

Online learning technology began in the mid-1990s as a means of delivering electronic educational content via the Internet. Over the past decade, web-based learning has become a trend to connect the vast array of digitized content to students, to utilize interactive and multimedia learning methods in the classroom, and to tailor pedagogy to the needs of the student by using the computer "to make [a] reasonable guess about the difficulties a student may have in understanding a concept and provide appropriate help" (Rothkopf, 2009, p. 6). This customized learning environment was not practical previously or available in the traditional classroom, and the convenience of this technology (in its ease of accessibility and number of resources) is an added incentive to the student.

The number of resources and web-based pedagogical/learning supports has increased steadily as this trend has continued (Kelley & Orr, 2003). The most comprehensive resources are collaborative projects with support from universities or non-profit groups. The National Science Digital Library (NSDL) was created in 2000 by the National Science Foundation to "provide organized access to high quality resources and tools that support innovations in teaching and learning at all levels of science, technology, engineering, and mathematics (STEM) education" (About NSDL, para.1). Its library of "exemplary resources" for education and research was designed primarily for K-16 teachers. Other resources specifically for mathematics include *Convergence*, which emerged from the University of Kentucky at Knoxville, and the *Statistics Online Computational Resource* (SOCR), created by the University of California, Los Angeles. While these existing online resources are useful in terms of content and variety, their pedagogical effectiveness and efficiency have not received adequate testing (with the exception of Dinov's 2006 "quasi experiment"). Additionally, they can be overwhelming to the first-time instructor who seeks to create a quality-learning environment but has little time or experience with web-based resources.

Open Resources and APIS Learning

One of the more recent trends in web-based learning is the Open Educational Resources (OER) movement. According to Baraniuk and Burrus, the OER movement is based on the following premises:

> knowledge should be free and open to use and reuse; collaboration should be easier, not more difficult; people should receive credit and kudos for contributing to education and research; and concepts and ideas are linked in unusual and surprising ways, not necessarily the simple linear forms that today's textbooks present (2008, p. 30).

The OER movement was primarily fueled by students and teachers who were frustrated with the high costs of textbooks and the restrictions in distribution and collaboration; however, the movement has led to several advances in online learning. The use of XML and Java programming languages has led to the development of modules that could be configured (and reconfigured) into a customizable system. Taking inspiration from the open-source evolution in the computer-software industry, partnerships between for-profit organizations and educational institutions have enabled the development of textbooks and online resources that cost a fraction of their commercial value. While there are numerous stumbling blocks to the adoption of OER (*i.e.*, intellectual-property fragmentation, lack of quality control, and few success models, to name a few), the advantages of collaborative pedagogy and a module system are attractive characteristics in future web-based learning development.

A potential solution to the challenges of web-based learning is to guide and filter the vast array of online pedagogical tools into a useful learning model. A Pedagogical Information

System (or APIS) was designed by Dr. Ernst Rothkopf, Professor Emeritus of Columbia Teachers College. He defined APIS as:

> a loosely organized, highly redundant collection, in polymorphic digital forms, of explanations, demonstrations, simulations, interactive exercises, problems, examples, elaborations, integrative expositions, as well as a deep, searchable information base. (Rothkopf, 2009, p. 2)

Rothkopf encouraged the utilization of a pedagogical framework that would require the teacher to use multiple modes of learning (and redundancy) to produce a deeper proficiency among students. In a way similar to the OER approach, the APIS system is organized into modules, or distinct sections, such as videos, exercises, databases, encyclopedias, games, etc. Modules, which emphasize a variety of active learning processes, are intended to give the student (and teacher) a variety of ways to read, practice, research, and learn. They also facilitate a more natural and inquisitive method of learning, which is a primary advantage of web-based instruction. Rothkopf's APIS system has never been tested fully and realized, but he makes an effective argument against the existing problems in traditional pedagogy and describes potential solutions through web-based learning.

Although there are a variety of learning styles, two dominant cognitive styles have been studied most often in traditional mathematics teaching: *constructivism* and *socio-culturalism* (Engelbrecht and Harding, 2005). As a result, other cognitive styles are usually not emphasized in statistics pedagogy. These conclusions could change, however, within the unique context of e-learning, which allows the instructor to deliver customized content and interactive multimedia.

There is scant literature on statistics pedagogy and even less on web-based teaching and learning methods for statistics. This is primarily because research has focused on pedagogy and subject matter separately (Wallace, 2004). Pea (1987) argued that although the computer has the potential to promote dialogue on mathematical problem-solving, computers have rarely been used to facilitate this function (p. 105). We know even less about how web-based learning might differ across subject matters. Only a decade ago, Becker (1996, p. 78) found that just 30% of the literature on statistics teaching was based on empirical studies, and that 20% of these studies focused on technology, or Computer-Assisted Instruction (CAI); these figures remain largely unchanged. While these gaps may seem fundamental, Engelbrecht and Harding (2005, p. 253) confirmed that “a pedagogy for driving online courses in mathematics is still only in its development phase.”

Purpose of the Study

The purpose of the study is to examine issues of efficacy, efficiency, and effectiveness in the use of Internet websites in the instruction of introductory statistics at the college level. “Efficacy” includes perceptions of competence and confidence in instructors of introductory statistics concerning their abilities to use the Internet as a teaching device. “Efficiency” relates to the improvement of instructional time that web-based resources can provide to introductory statistics instructors. “Effectiveness” refers to the ability of web-based resources to enhance the learning process so that students learn statistical concepts more thoroughly and completely than they had been without web-based sources.

This study will seek answers to the following questions:

1. What problems (pedagogical and practical) arise in the design, organization, and compilation of web-based elementary statistics learning material?
2. What areas of statistics are particularly appropriate for APIS?

3. How do professionals involved in teaching statistics react to the web-based material?
4. What are the pedagogical and practical changes that elementary statistics teachers need to undertake in order to enhance the use of web-based, self-access, elementary statistics material to support the learning of the target group?

Each question represents a particular deficit in e-learning pedagogy at various stages of the teaching process, from course design and implementation to interaction and feedback. The first question relates to problems instructors encounter in incorporating web-based technology into their classrooms. The second question concerns what statistical topics they would like to see included in a web-based clearinghouse. The third question focuses on statistics instructors' perceptions of the material available to them on the Internet. The fourth question concerns the evaluation of existing sources and suggestions for improvement of Internet-based resources that would help their particular students learn statistics.

Procedures of the Study

Research Design

The design of the study is qualitative and uses a phenomenological interpretive method. This means that participants were interviewed about their experiences in using Internet sources for instruction of students in introductory statistics courses. The research questions stated above were the focus of the interviews. The method of data collection was semi-structured interviews.

Sample and Population

The population of the study consists of instructors of introductory statistics courses at the undergraduate level in two-year and four-year academic institutions in the New York metropolitan area. From this population, a convenience sample of 4 participants was chosen to be interviewed by the researcher.

Instrumentation

The instrument that was used for data collection in this study was an interview protocol with open-ended questions. The protocol contained general demographic information, including gender, highest degree, when highest degree was granted, areas of specialization, years at present institution, institutional provenance, institutional type (2-year or 4-year), number of years teaching introductory statistics, and so forth. Demographic data was followed by approximately 15 questions related to instructors' experience and perceptions about their use of Internet-based resources for the instruction of introductory statistics. The approximately 15 questions were directed at answering the four research questions stated above. Interviews took approximately 60 minutes.

Procedures

The sample was collected initially by recruiting instructors who were known to the researcher. The snowball technique was used to recruit other potential participants in the study by asking willing participants to nominate other instructors of introductory statistics for possible inclusion in the study. The researcher contacted potential participants personally, by telephone or email. Upon contact, the researcher described the study in general terms and described the nature and time commitment required for participation. The researcher then discussed how confidentially, their right of refusal without retribution, and their right to have access to the findings of the study would be guaranteed. The researcher invited the instructors to participate in the study. If a potential participant agreed to be interviewed, then arrangements were made to conduct the interview.

At the interviews, the researcher read a standardized statement to the participants about the purpose of the study, rights of participants, risks and benefits of participation, and access numbers and/or email addresses of the principal investigator. The researcher then began the interview. At the end of the interview, the researcher asked the participants if they had any questions or concerns about the interview process. Once those concerns were addressed, the interview was concluded. Any participant wanting a copy of the results of the study will be emailed a copy of the dissertation abstract at the completion of the work.

CHAPTER II

LITERATURE REVIEW

This chapter contains the background knowledge supporting this thesis and its importance to introductory statistics education and instruction. This chapter is divided into four categories: (a) reformation of statistics education in introductory statistics, (b) technology in the classroom, (c) overview of web resources for teaching statistics, and (d) barriers in using technology in the statistics classroom. Each section is aligned with the research questions and will answer them accordingly.

The rapid growth of the technological tools available in today's world has changed the landscape of teaching and learning statistics. In statistics a great attention is given to how to make students understand and know how to apply statistics. Learners and instructors of statistics need clear and accessible teaching tools. Applications, step-by-step tutorials, explanations, demonstrations, simulations, interactive exercises, problems, examples, elaborations, integrative expositions, and data graphics are extremely useful for teaching students to think scientifically and use proper techniques. Technology is an excellent way to present difficult or abstract statistical concepts and it is advantageous for students and teachers to enhance their classroom learning. Although the use of online learning environments in education is increasing, the literature in which statistical issues and the web have been discussed systematically is limited (Tishkovskaya and Lancaster, 2012).

Reformation of Introductory Statistics Education

For the last two decades, the statistics education community has been actively engaged in reform, with a focus on college level introductory statistics courses (Hassad, 2014). According to Loftsgaarden and Watkins (1998), there were an estimated 236,000 students enrolled in post-secondary elementary-level statistics courses in the Fall of 1995. The number of students taking introductory statistics has increased (Shaughnessy, 2007). The main reasons being: statistics has gained recognition as an essential subject at all levels of education, the existence of a consensus among statistics educators that statistics should be an integral part of the post-secondary curriculum (Cobb, 1992; Hogg, 1992; Moore, 1993), and that the introductory statistics course is being taught by faculty in other departments such as psychology, sociology and business. (Garfield, Hogg, Schau, and Whittinghill, 2002)

The National Science Foundation (NSF) has funded numerous projects to implement aspects of reform (Cobb, 1993). Moore (1997) noted the reform in terms of changes in content, pedagogy and technology. These changes have been found to be effective (Garfield et al., 2002) and are endorsed by the American Statistical Association (ASA) and the Mathematical Association of America (MAA). Richard Schaeffer states that "with regard to the content of an introductory statistics course, statisticians are in closer agreement today than at any previous time in my career." (Moore, 1997, p.156)

The initial charge for reform was the COBB Report, entitled *Heeding the Call for Change: Suggestions for Curricular Action* (Cobb, 1992). As a result of the surge in technology usage and changes in the professional practice, George Cobb recommended change for the college-introductory statistics course. He organized a focus group to set up teaching guidelines.

They produced a paper called "Teaching Statistics" that emphasized three recommendations; a) emphasize statistical thinking; b) present more data and concepts, less theory and fewer recipes; and c) foster active learning. A survey of instructors of introductory statistics at the end of the decade was produced signifying the effect of Cobb's recommendations (Garfield, 2000). It showed that introductory statistics instructors were following the recommendations. In response to the rapid increase in enrollment of students in undergraduate statistics courses and the increase in placement of students into advanced placement statistics courses (Shaughnessy, 2007), the Guidelines for Assessment and Instruction in Statistics Education (GAISE) were established.

The GAISE Report

In 2005 the board of directors of the American Statistical Association (ASA) approved the Guidelines for Assessment and Instruction in Statistics Education report which was developed by a group of statisticians and statistics educators with funding from the ASA. The report included two sections, one for K-12 and one for college-level instruction. The purpose of the GAISE college report (ASA, 2005) was to establish a developmental framework, building upon the 1992 report written by George Cobb. The report's recommendations were intended to encourage statistics instructors to modernize introductory statistics courses and make them engaging and authentic (Zieffler, Park, Garfield, DelMas and Bjornsdottir, 2012).

The GAISE report listed six recommendations for the teaching of introductory statistics. They are:

1. Emphasize statistical literacy and develop statistical thinking
2. Use real data
3. Stress conceptual understanding, rather than mere knowledge of procedures

4. Foster active learning in the classroom
5. Use technology for developing conceptual understanding and analyzing data
6. Use assessments to improve and evaluate student learning

Following the six recommendations, the GAISE college report concluded with suggestions for making the changes and provided many examples illustrating the implementation of the recommendations. Even though the GAISE report offered a guideline for statistics educators and served as an aid for students' learning, the guidelines are not simple to implement, particularly its recommendations to use technology, given the rapid changes in the field.

The GAISE recommended:

> A greater use of active learning and a larger emphasis on conceptual understanding, together with the use of technology to analyze data and to develop understanding of conceptual tools with active learning to teach concepts related to inference via computer simulation (Fry, 2014, p. 1).

According to Hassad (2009), introductory courses, such as statistics, serve as an introduction to the fundamentals of the discipline and also serve as a basis for further study within the field. Moreover, the importance of an introductory course can shape students' beliefs and attitudes toward a certain discipline (Dallal, 1990; Moore, 1997, 2005). Therefore, stressing the importance of the introductory course in statistics, Hassad (2009) expressed the spirit of reform-based teaching of introductory statistics:

> The teaching of introductory statistics is intended to facilitate statistical literacy, thinking, and quantitative reasoning, through active learning strategies, by emphasizing concepts and their applications rather than calculations, procedures and formulae (p. 2).

Technology in the Classroom

Tamim, Bernard, Borokhovski, Abrami, and Schmid (2011) analyzed more than 40 years of investigations to answer the question, "What is the effect of using computer technology in classrooms as compared to no technology, to support teaching and learning?" The authors found that "the extracted effect sizes… revealed a significant positive small to moderate effect size favoring the utilization of technology in the experimental condition over more traditional instruction (technology free) in the control group" (p. 16). Further analysis revealed that computer technology that supports instruction had a significant effect compared to technology applications that provide direct instruction.

An important change that has had a significant impact on the teaching and learning of statistics over the past few decades has been the integration of computers (Mills, 2002). Cobb (2007) stated that "teachers of statistics who care about doing well by their students and doing well by their subject have recognized computers are changing the teaching of our subject" (p. 1). Computers and statistical software have had a major influence in the classroom and on the teaching of statistical methods. Microcomputer development has brought on the development of more user-friendly statistics packages, such as SPSS, SAS, and Excel, which allow students to complete computational tasks more efficiently, thus allowing more focus on statistical concepts. These types of statistical packages are being used with increased frequency in introductory statistics classes (Chance, Ben-Zvi, Garfield, & Medina, 2007).

Chance et al. (2007) insist that "It is hard to imagine teaching statistics today without using some form of technology" (p. 1). The authors offered an overview of important technological tools students can use to better understand new statistical course content, pedagogical methods, and instructional formats. Some of the tools that increase student literacy include graphing calculators, computer labs where students use their own laptops with statistical software, the internet, video-taped lectures, interactive discussions, collaborative projects, and e-texts. These tools continue to evolve over time. It is important to understand impact of technology on the content, pedagogy, and course structure in order to have students comprehend the subject matter.

According to Garfield, Chance and Snell (2000), the types of technology used in statistics education toward the end of the 20th century fell into the following categories:

- Statistical packages and spreadsheets for analyzing data and constructing visual representations of data
- Multimedia materials to teach, tutor , and/or test students' statistical knowledge and skills
- Web or computer-based tools, including simulations, to demonstrate and visualize statistical concepts
- Graphing calculators for computation, graphing, or simulation
- Programming languages that students can use to set up more complicated simulations or numerical analyses

Given the large amount of technology readily available for use in teaching statistics, it is questioned whether these tools can be used to improve students' statistical reasoning abilities (Zieffler, Garfield, Alt, Dupuis, Holleque, & Chang, 2008). Lane and Tang (2000) surveyed 115 college students to test the effectiveness of teaching statistical concepts using simulations compared to a textbook. The authors found that the subjects trained by simulation performed significantly better than those trained with only a textbook.

In contrast, the findings of Zieffler et al. (2008) are somewhat conflicting (with those of Aberson, Berger, Healy, Kyle, and Romero, (2000). The authors evaluated the effectiveness of a web-based interactive tutorial, in which 111 students enrolled in a statistics class used either the interactive tutorial or took a lecture group. It was found that both groups improved from pretest to posttest with no significant differences. One possible explanation of the differences is because of technological development in instructional techniques between 2000 and 2008. This study provided evidence that an "internet tutorial can be comparable in effectiveness to a good lecture or demonstration in fostering learning about a core statistical concept" (p. 291). Although a substantial amount of literature exists on the use of technology in statistics education, scant literature focuses on the development of the technological skills required to use it. Further studies could address the following important questions in the field of statistics education, specifically: What barriers could arise when developing technological skills? What are the cognitive processes involved in the learning of technology?

Incorporating technology in the classroom has great potential to enhance instruction and student learning. However, turning it into a reality has its own obstacles. Teachers should be mindful of such obstacles when using technology's benefits (Hall & Rowell, 2008). Rubin (2007) discussed two issues about incorporating technology in statistics education. They are: a) computers may make graph construction too easy, causing students to lose the opportunity to determine axes, scales and other areas of graph design, and b) students sometimes think that computers are always right and are unlikely to question anything the computer produces.

With the rapid advancements in technology, the classroom environment is constantly changing and will continue to change. The development of the World Wide Web (WWW) has produced a means for instructors to share their ideas on ways to improve statistics education.

Overview of Web Resources for Teaching Statistics

According to Wang (2007) instructors in higher education are putting great effort to improve the quality of teaching practices. The Internet serves as a great resource in assisting their efforts. Wang said, "The academic potential of the internet will not be fulfilled unless it is integrated in university courses to impact (*sic*) student learning" (p. 279). It is commonly recognized that the internet offers innovative methods for teaching in general and specifically for statistics.

The Web is universally used to store and disperse information. "Over the better part of the last decade, the WWW has garnered massive attention and growing credibility as an academic tool," (Hyman, 2003, p. 17). Currently, many university statistics courses have their own websites. These sites may contain places to store lecture notes, PowerPoint presentations, data sets, exercises, and so forth (Phillips, 2003, p.6). These internet resources may include web applets, data sets, text materials, assessment items and a vast collection of links to websites that inspire and motivate teachers and students.

The number of resources about statistics and self-taught material on the Web has increased and has molded the way in which statistics is being taught (Tishkovskaya & Lancaster, 2014). There are many websites available and it is difficult for teachers of statistics to select those that are most useful. Tishkovskaya and Lancaster provide an overview of the status of Web resources for teaching statistics. They grouped the resources into subsets based on their purpose. The resources they have gathered are compiled into the following groups:

1. *On-line statistical course materials and lectures.* An increase in online courses and online statistical information has resulted from fast developing technology and a surge of

student enrollment. These classes are structured to support web or hybrid classes and to facilitate independent teaching and learning.

2. *Learning repositories and teaching materials.* Online resources for learning statistics have gained popularity in recent years. They contain materials that engage the user (students, faculty, and staff) and vary in type and format for customized learning styles.

3. *Web-based data resources and repositories.* The web houses many sites that provide real life data sets. This enables teachers to capture the attention of students by offering them realistic exercises.

4. *Online statistics textbooks.* A growing number of private groups are developing statistics textbooks and textbook-related websites for students. These sites provide information and serve as an additional source of learning

5. *Statistical literacy.* Online statistics associations and websites exist to help increase statistical knowledge.

6. *History of statistics.* Teachers can use the experiences of historical counterparts to gain the interest of their students by applying them to real situations. This information can be used to assist students in the classroom and in their homework assignments.

7. *Electronic journals on statistics education.* Electronic journals are gaining popularity; they increase accessibility and decrease the lack between research and publication. Researchers and instructors are provided updated information about innovation. By referencing these published articles, teachers are able to enhance their classes.

8. *Data visualization.* Technology allows people to visualize concepts that otherwise would be difficult to understand by use of demonstration. This also enables people to be able to teach these concepts to others.

9. *Statistics Applets.* Online demonstration applications enhance instruction. Sophisticated illustrations can assist in statistics education.

10. *Miscellaneous links related to statistics.* Statistics web links created and maintained by experts are available online for teachers to use as a resource. These sites serve to help instructors teach the course and motivate students.

Websites may present a massive amount of material, but may also contain misinformation, incomplete instructions, contradictions, or out-of-date material (Ooms and Garfield, 2008). According to Branch, Kim and Koenecke (1999) the inconsistent quality of internet resources may partly be due to the shortage of review processes available to regulate the credibility, quality, and accuracy of published websites. Students may be exposed to misinformation retrieved by the instructor. Branch et al. provide seven major topic areas to consider when evaluating web-based online educational materials. The topics are specifically:

- *Judge the accuracy of the information and take note of the date modified.* Is the information current? Does the site come from a reputable source?
- *Make sure the level of information in this site is appropriate for the intended audience.* Is the information for the intended learner?
- *Have the information presented clearly.* Is the information presented clearly and in an organized fashion?

- *Have the information in the site related to purpose, content, activity and procedures.* Is the site relevant? Is the site redundant? Does it relate to the objectives?
- *Make sure the information in the site is complete in scope and is ready for use.* Does the site contain depth of information related to the topic? Are there any gaps in concept development?
- *Make sure the website's activities' content, presentation method and learner activity is engaging.* Are the activities challenging, interesting, and appealing? Does the site promote learner action? Does the site have the potential for developing confidence?
- *If you make claims to be comprehensive, make sure the information in the site is well organized.* Does the information flow and do the segments relate to one another? Are references and supporting evidence provided?

Barriers in Using Technology in the Statistics Classroom

Incorporating technology into statistics classrooms has the ability to improve student learning and instruction; however, "turning it into a reality can be a complex and multi-faceted task" (Chance et al, 2007, p. 17). Several barriers hamper effective technology integration in the general classroom. The two significant barriers identified in the literature are teacher attitudes towards technology and effective training.

Existence of technology barriers in the statistics classroom have been noted as early as the 1980's. According to Thisted and Velleman (1992) four obstacles hamper incorporating technology into college statistics courses. These include equipment, software, projections, and obsolescence of technologies.

Some common obstacles discussed by Chance et al. (2007) that teachers face when integrating technology into their statistics classrooms and the essential strategies to overcome them are:

1. *Need to Re-examine Student Learning Goals* (Chance et al., 2007, p.17). Changes need to be reflected in course goals and student assessments when incorporating technology. At the college level, colleagues and administrators must adapt to changes in learning outcomes due to the use of technology. For example, doing away with hand calculations and instead relying on software to compute values such as *t*-test.
2. *Lack of Awareness of and Comfort with New Technologies* (Chance et al., 2007, p.17). Statistics is a specialized subject of mathematics. It requires teachers who are open to incorporating new technologies into their classrooms. Teachers who have been teaching for a while may be resistant if it requires a substantial amount of their already limited time to learn how to use these programs. Their lack of familiarity may cause hesitation. Long-term support to learning how to implement technology will be required for teachers to completely incorporate technology into their classrooms. The internet-based communities of teachers can be a tool to help instructors implement technology.
3. *Lack of Support for Teachers* (Chance et al., 2007, p.18). Many schools are not effectively incorporating technology into their classrooms because of the lack of administrative support despite extensive content that is available. Administrative support must be provided to fund computer labs, technical support, and professional development for teachers in an ongoing approach. It is vital for teachers to continuously assess course

content and their new pedagogies to measure the effectiveness of their teaching and maximize the benefit of their students' learning. Technology alone does not make for effective teaching.

4. *Class Time Required for Exploration* (Chance et al., 2007, p.18). Although time consuming, a key benefit of using technology in the classroom is student exploration of problems and concepts and the analyzing of complex data sets. Time can be saved by omitting unnecessary sections of class instruction, elimination of hand calculations, and replacing them with topics of discussion that are more beneficial to the student. Students' education of such exploration at the lower grade level could result "in increasing student comfort with such exploration and perhaps leading to a less impacted curriculum at the college level" (p. 18).

5. *The Fact that Technology Can Fail* (Chance et al., 2007, p.18). It is important for both teachers and students to be aware that technology can fail. They have to be prepared for and comfortable with the unexpected. Teachers must be ready to step in with prepared lesson plans that allows the class to continue to function.

6. *Time Needed to Implement Changes* (Chance et al., 2007, p.18). Teachers must realize that it is not realistic to expect immediate improvements from the integration of technology. Effective use takes refinement and continuous assessment and modification. Teachers are preparing students for their roles in future positions. Although their instruction may not show immediate success, they are teaching students how to use technologies that may be beneficial in their futures.

7. *Unclear Role of Distant Learning* (Chance et al., 2007, p.19). New ways of using technology are being developed for distance learning. However, it is unclear how much

of a course can be taught entirely using technology and what the roles of an instructor should be. Hybrid courses— those that combine distant learning with infrequent fact-to-face classes are gaining popularity.

According to Symanzik and Vukasinovic, 2003 it is challenging to obtain and use a substantial amount of statistics-related material on the web. The amount of time and thought is needed to implement software packages may be substantial (Chance et al., 2007). Even though technology has endless capabilities, educators need to be mindful of using sophisticated software packages that may result in the students spending more time learning the computer software than the course material. Statistics instructors need a system to assess existing web sites and their educational components (Ooms & Garfield, 2008).

This chapter provided information about the reformation of statistics education in introductory statistics, technology in the classroom, overview of web resources for teaching statistics, and barriers in using technology in the statistics classroom. The following chapter, Chapter Three, will provide a description of the methods and data collection procedures used in this study.

CHAPTER III

METHODS

Research Design

In selecting my research framework I needed to decide what kind of study would be most appropriate. For this study a quantitative approach was not suitable because, as Smith, Flowers and Larkin (2009) point out, quantitative research focuses on "what happens" (p.46), and when thoughts, emotions, and meanings are part of the topic, it is difficult to observe what happens directly. Therefore, I chose the qualitative framework, which tends to focus on "personal meaning and sense-making" (Smith et al., p.45). More specifically, I used the interpretative phenomenological analysis (IPA) approach "to focus upon people's experiences and/or understandings of particular phenomena" (Smith et al., p.46). Participants were interviewed about their experiences using Internet sources for instruction of students in introductory statistics courses. The research questions were the focus of the interviews.

Participant Selection

I employed purposive or judgment (Marshall, 1996) sampling of four (4) professors who currently teach elementary statistics. According to Smith et al. (2009), between three and six participants can provide an adequate number of cases for the development of "meaningful points" (p.51). Therefore, I chose four willing and available participants. The participants had to be full-time professors and instructors working in college-based statistics classes in a single state in the Northeastern United States. Given that I am investigating teachers and educators working in the field of statistics, I did not include adjuncts or other part-time faculty members because many of them may hold other professional positions, causing them to have different attitudes and beliefs about how statistics should be taught. I did not restrict the participant pool based on type of college or university.

Participants were chosen based on their voluntary response to my invitation to participate. An invitation was sent by email to the institutional addresses of these instructors at colleges throughout the New York metropolitan area. I began by contacting my own acquaintances. I proceeded by including “snowballing” contacts that were recommended by my participants as useful potential candidates.

Participant Background

The following provides a personalized look into the professional backgrounds of the participants involved in this study:

P1 has been a college professor for over thirty years. She completed her undergraduate degree in mathematics and statistics. During P1’s tenure as a college instructor, she has taught various mathematics and statistics courses. Throughout the early portion of P1’s teaching experience, she completed a Masters of Science in Biostatistics and a Masters of Science in Applied Math and Statistics. Upon graduating, P1 started her career as a biostatistician. Shortly after completing her doctoral program in math education, she received an offer at a university to serve as a statistician/assessment specialist for the dean’s office. This is where she extracted and analyzed data using various statistical software packages. P1 was asked to teach graduate level courses in statistics and also supervised doctoral candidates and fellow faculty members in their statistical analysis. P1 has a very diverse higher education teaching background. She returned to full-time teaching and currently works at a four year college teaching mathematics and introductory statistics courses. P1 believes in engaging her students and utilizes numerous websites in her introductory statistics courses to help them be active learners.

P2 is a professor of mathematics and statistics. Before joining the teaching profession, P2 completed a Masters of Arts degree in Mathematics and a Masters of Science degree in Statistics. He has been teaching Introductory Statistics for over twelve years, and he heavily incorporates technology in the classroom. Further, P2 is a tenured faculty member at his current institution, where he serves in his role as a mathematics and statistics educator in the department of mathematics. He has been teaching in higher education for fourteen years and has taught introductory statistics each semester during this time. P2 is an active researcher who investigates studying statistics via randomization utilizing simulation tools. His areas of expertise reside in statistics pedagogy and in the integration of technology in instruction.

P3 is an assistant professor of mathematics and statistics. He has been teaching in higher education for seven years. P3 earned a Masters of Science degree in Mathematics; during his studies, he had the opportunity to take numerous graduate statistics courses. P3 is a tenure track faculty member at his institution, where he serves in the role of mathematics/statistics educator in the department of mathematics. Additionally, like P2, P3 is involved in conducting research investigating studying statistics via randomization utilizing simulation tools. P3 was asked to teach several sections of introductory statistics in his department because of his success and knowledge.

P4 is a tenured faculty member in the department of mathematics. He has been teaching for over ten years at the college level. P4 grew up wanting to be a teacher. After graduating from college he pursued his Masters in Mathematics at New York University, where he had the opportunity to take numerous statistics courses which he highly enjoyed. Following his master's degree, P4 began his career as an instructor in mathematics and statistics at a four-year, private institution in New York. He later earned his doctorate. His research focuses on statistics education and developmental mathematics. Currently, he works for a state college. His background includes two years as a statistical educational consultant. P4's teaching philosophy is that mathematics and statistics must be used as an avenue to bolster a student's critical thinking and problem -solving skills. Technology plays a large role in his introductory statistics courses. Students need to have a statistical calculator that can perform multiple functions. All course material is available on the web and many out-of-class assessments, such as homework assignments and examinations, utilize the Internet. He uses Internet websites as supplementary course material in the classroom and also uses various types of Internet-based software such as MyStatLab. All course material is on the Internet and homework includes some online exercises with links to other statistical websites. In class, he incorporates various interactive statistical demonstrations and tutorials.

Data Collection

With each of the purposefully selected individuals, I conducted a semi-structured individual interview (see protocol in Appendix A) with each of the carefully selected individuals and indicated to each participant that the in-depth interview would last approximately 60 minutes. I met each of the participants in person at a time and place of his or her convenience. According to Sanders (1982), the semi-structured interview is one of three effective methods for data collection in a phenomenological study. The interview structure utilizes open-ended questions that are informal and engaging for the participant. During the interview process, verbatim notes are taken according to the responses of the participants to ensure meaningful and appropriate follow-up. Each interview focused on the participant's experiences and perceptions about his/her use of Internet-based resources for the instruction of Introductory Statistics. Each interview was noted verbatim, and transcripts were generated. I used the software Dragon to transcribe the interviews. Throughout the interview process, notes were taken according to the responses of the participants to obtain meaningful and appropriate follow-up questions for the purpose of clarification and elaboration (Rubin and Rubin, 2012).

Organizing the data collected and gathered from the interview was critical throughout the interpretation and analysis segments of the study. The data collected was organized by filing the transcribed interviews in a different manila file folder for each participant. In addition, electronic documents were organized in folders specific to each research participant.

Data Analysis

There is no single approach for IPA. The approach underpinning IPA is that "the essence of IPA lies in its analytic focus" (Smith et al., 2009, p.79). IPA analysis is known for the repetition of steps and interpretation. It gives the analyst the freedom to understand the essence of the participant's experience by using a different process, such as moving between particular and general and descriptive and interpretative. The researcher needs to be flexible, insightful, and creative.

Qualitative researchers, including those using IPA, facilitate a set of steps for the researcher to analyze his or her data. For this research-analysis section, I employed the set of steps for IPA suggested by Smith et al. (2009). IPA has six steps for analyzing the transcripts which include: (a) reading and rereading; (b) initial noting; (c) developing emergent themes; (d) searching for connections across emergent themes; (e) moving to the next case; and (f) looking for patterns across cases.

Step one: “Reading and re-reading” of the interview transcripts (Smith et al, 2009, p.82). This first stage “is conducted to ensure that the participant becomes the focus of analysis” (p.82). I dedicated a substantial amount of time to understanding each participant’s phrases and/or metaphors while maintaining the emphasis on the participant rather than on the researcher’s own experiences. I tried to be mindful of my own thoughts and feelings.

Step two: “Initial noting” (Smith et al., p.83). My goal was to generate a “comprehensive and detailed set of notes and comments on the data” (p.83). This step enabled me to become more familiar with each transcript and understand the participant’s perception as I started to write comments and notes on the transcript. There were no guidelines on what was commented on, but suggestions were given. These comments were descriptive, had a “phenomenological focus and stayed close to the participant’s explicit meaning” (p.83). I tried not to deviate from the participant’s explicit meaning regarding the phenomena. This step offers three different levels of processing the initial noting.

The three levels are descriptive comments, linguistic comments, and conceptual comments. At the descriptive comments level, “initial notes is very much about taking things at face value” (Smith et al., 2009, p.84), highlighting the objects and putting some kind of structure to the participants’ thoughts and experiences. The analyst also needs to capture the participants’ assumptions, emotional responses, acronyms, and phrases. At the linguistic comments level, the analyst is concerned with the participants’ language and focuses on whether the “transcript reflects the ways in which the content and meaning were presented” (p.88). The following level of the initial noting is conceptual comments. This level incorporates an element of personal reflections, and the interpretations are drawn on the researcher's knowledge. This approach is a main benefit of IPA, given that I am able to draw on my own knowledge as a mathematics and statistics educator.

Step three: "Developing emergent themes" (Smith et al., 2009, p.91). This phase caused me to analyze the whole interview, turning it into a set of parts that then became a whole again in the write-up section. As suggested, I worked with the initial notes, and started to break up the initial notes from the interview into different relevant categories. This stage required me to begin "mapping the interrelationships, connections and patterns between exploratory notes" (Smith et al., 2009, p.91). My main focus of the emergent themes was to reflect on the participants' original thoughts.

Step four: "Searching for connections across emergent themes" (the analyst's interpretations of such thoughts; Smith et al., 2009, p.92) enabled me to put all the themes that were related to each other into groups. Similar to step two, this level has no rules or requirements, but, rather, suggestions to provide encouragement "to explore and innovate in terms of organizing the analysis" (p. 96). During this step, there is the possibility of identifying a "like with a like and developing a new name for the cluster" (Abstraction) (p.96), taking into account the number of occurrences in which a particular *theme* is supported (Numeration) (p.98). The "drawing on ideas from discourse and narrative analysis," but joining with an obligation to the experiential (Function) (p. 98), is also possible.

Step five: "Moving to the next case" (Smith et al., 2009, p. 100). In this step, I reached the point of repeating steps one through step four for all the participants' transcriptions. I needed to be mindful of treating each case on its own, which means "as far as possible bracketing the ideas emerging from analysis of the first case while working on the second" (p.100), so new themes could appear in each case.

Step six: "Looking for patterns across cases" (Smith et al., 2009, p.101). This step allowed me to dig deeper for a richer interpretation. The final result of this process shows a connection throughout the group as a whole and is usually done by forming a "table of themes for the group and illustrating the theme for each participant" (Smith et al., 2009, p.101).

For steps three to six I created an Excel spreadsheet to organize my efforts in my qualitative data analysis (See Appendix B). The spreadsheet is broken down by interview question. Each questionnaire item has its own distinct page. The interview question is at the top of the page, participant identifiers at the leftmost column, topics generated by participants at the top (below interview question), and information shared by respondents is located in separate cells under each topic to which they correspond. This allowed me to reference my themes to the questions being asked. Topics became themes once they were mentioned by more than one participant. Creating this spreadsheet made it easy to identify them by reading down the columns. Each individual topic mentioned by a participant was placed in a separate column and combined if it matched what another participant mentioned. Organizing this rich text-based data by participant and topic not only showed emergent themes, but it also allowed me to see the various opinions on the differing themes. This was valuable when analyzing the generated transcripts to help identify patterns for how the select group of participants responded to each of the research questions. It also allowed me to compare and contrast among my participants on the various emergent themes. Once I had my topics and themes organized, I looked to see which topics and themes answered each of my research questions.

For each research question I thought about whether I had a consensus or whether there were differing opinions and perceptions. I was mindful of what factors might be related to or influence my subject's opinions and perceptions. I established the empirical fact and then speculated on causes or influences or relationships. This part was interpretative. For example, in research question 2, "What areas of statistics are particularly appropriate for APIS?" I thought of the following: Are my subjects going to agree on appropriateness? If so, why do I think there is such an agreement? If there is a disagreement, or a variety of opinions, why do I think they exist? Who is on one side and who is on the other? What is associated with the differences? Is it teaching philosophy, type of preparation, or experience?

CHAPTER IV

RESULTS

Four research participants were interviewed with the intention of answering four research questions:

1. What problems (pedagogical and practical) arise in the design, organization and compilation of web-based elementary statistics learning material?
2. What areas of statistics are particularly appropriate for APIS?
3. How do professionals involved in teaching statistics react to the web-based material?
4. What are the pedagogical and practical changes that elementary statistics teachers need to undertake in order to enhance the use of web-based self-access elementary statistics material to support the learning of the target group?

Data analysis revealed key areas that were organized by order of the questions presented to the participants. Interviewee commentary also provided transition and depth to the supporting areas. At the end of Chapter IV, this researcher will provide a summary of the perceptions and experiences of the participants. The questions posed to the interviewees were developed to grasp an understanding of their perceptions and experiences of using Internet sources for instruction in introductory statistics courses.

Interviewees, identified as P1 (participant 1) through P4 (participant 4), represent a sampling of college/university professors and instructors who teach college-based statistics classes in the State of New York. A semi-structured individual interview, which lasted approximately 60 minutes, was conducted for each subject at a mutually convenient location.

This chapter will follow a structured outline format that follows the interview itself. A total of fourteen (14) questions were posed to each participant. Interview questions 1 through 3 were used to allow the participants to open up and begin speaking. Interview questions 4, 5, and 6 answer Research Question 1. Question 7 answers Research Question 2. Interview question 8 answers Research Question 3. Interview questions 9 and 10 answer Research Question 4. Interview questions 11-14 are additional themes not based on the original research questions. These questions are purely exploratory with no preconceived expectations. This section will capture the key areas of each individual interview question. Block quotations are used to provide a personal connection to participants' voices, which will allow the reader an overall understanding of the interviewees' experiences and perceptions to each question.

Research Question 1: Problems in Web-Based Learning Materials Research

Question 1 asked, "What problems (pedagogical and practical) arise in the design, organization and compilation of web-based elementary statistics learning material?" In order to answer this question, the four study participants replied to three questionnaire items. Questionnaire item 4: In your experiences as a teacher what problems arise in the design of web-based introduction to statistics learning material? What problems could arise in the design of a web-based elementary statistics learning material? Questionnaire item 5. In your experiences as a teacher what problems arise in the organization of web-based Introduction to statistics learning material? If you do not have experiences in organizing web-based material how do you think it should be organized? Questionnaire item 6. In your experiences as a teacher what problems arise in the compilation of web-based Introduction to statistics learning material? If you do not have experiences in the compilation of web based material how do you think it should be compiled?

The four study participants' responses to the three questionnaire items will be analyzed separately.

Design

Interviewees responded with four problem areas that can arise in the design of web-based introduction to statistics learning material, specifically:

A. Resources

B. Software Training

C. Teaching Methods

D. Content

A: Resources. Based on their experiences and perceptions, participants discussed what they saw as the greatest problems in the design of web-based introduction to elementary statistics learning material. Both P1 and P3 discussed the importance of having the correct resources and having them easily accessible.

> The problems I see in the design of a web-based statistics course is finding the correct resources and having them ready at your fingertips the moment you need them in class. They have to be suitable for the 20 firewalls the college has for protection so, you have to figure out with your supervisor, your chair and your IT department if the software is okay to use. I also have a laptop, so you don't only have access to it in class—you can do it at home, or at the library or anywhere you choose. (P1)

> Having the right resources and support can cause some problems. Being able to access it when you need it is very important. (P3)

Participant 1 and Participant 3 agree that accessibility of the material is important. Accessibility means equal access and opportunity to all students. It also implies the need for flexibility to meet every user's needs.

B: Software Training. P3 also talked about how the lack of familiarity with the software could a problem and delay the learning process.

> Designing web-based introduction to statistics material and overcoming a learning curve tends to be a big concern that I have with those web-based materials because not a lot of students are going to be very familiar with web-based learning software and so there's always this initial hurdle that they have to overcome with getting used to the software itself first. And then once that's finally over, then they can start actually getting the learning benefits from the materials themselves. So there's that initial disconnect between the two that tends to cause some problems.

P3's experiences indicate that training is imperative for instructors and students. Insufficient knowledge creates frustration and causes a loss of interest for the course, affecting productivity.

C: Teaching Methods. P2 noted that there are multiple ways that statistics can be taught and how that could potentially be problematic.

> Problems that could arise in the design [of web-based introduction to statistics learning material]…there are multiple ways that statistics can be taught unlike many math classes where there is the traditional way that things get followed. Statistics has a variety of different styles that could exist. For instance, regression is a topic that sometimes depends upon the instructor's preference. It is taught early in a course and is sometimes taught late in the course after inference. As a result, how you attack… the problems themselves and the scenarios would be a little bit different depending on where you are within the course. That could potentially be something that's difficult to deal with. If all of a sudden you had students from different styles approaching things along those same lines, I would argue that the events of randomization based courses are really different from a traditional, old-fashioned statistics course. And, as a result students sometimes have a hard enough time being able to communicate between each other within those two classes much less be able to use the same resource for additional help.

P2 explained how different teaching styles can lead to problems. The way instructors structure their courses influences the student's overall experience. Professors need to find a way to foster critical thinking so that students don't resist this new approach to learning.

D: Content. P4 spoke about content and how it needed to be sufficient, organized, and readily available to avoid causing a problem in the design of a web-based introduction to statistics learning material.

> One problem that I foresee would be just making sure the right amount of material is on there. There's so much stuff and you want to include interest to this course. Making sure that all that stuff is readily available and that it exists will be one major problem. Making sure that whatever you design is organized in a way so that is easily accessible.

P4 is indicating that technology-rich learning environments improve instruction when they are designed, created, and refined in such a way that the content meets the needs of the user.

Organization

Questionnaire item 5 asked, **"**In your experiences as a teacher what problems arise in the organization of web-based introduction to statistics learning material? If you do not have experiences in organizing web-based material how do you think it should be organized?" P1 through P4 identified three problem areas that can arise in the organization of web-based introduction to statistics learning material:

A. Learning Styles
B. Time
C. Integration

A: Learning Styles. The participants discussed what they saw as key problems that could arise in the organization of web-based introduction to statistics learning material. P1 mentioned two areas of concern. First, he spoke about students' different learning styles. The repository would have to be organized in such a way that all students would be able to obtain the same information regardless of learning style.

> People learn in different ways. Everyone has different likes and dislikes. Not everyone absorbs the same information the same way. When you organize a site such as this you have to take that into consideration. You need to think about all end users and say, what can I do to ensure that everyone understands the information available. If you only focus on one style, then you have hundreds of students that won't benefit from it.

B: Time. P1 also discussed that the time it would take to organize such a site would be lengthy and a trial run would be necessary before it went live.

> A test run is necessary. You need to have the time to go through it for a couple of terms so that you can perfect it. There are always technological glitches that can occur and you want to make sure you iron out all the rough spots.

P1 indicated that different student learning styles and time are two areas that can potentially be problematic when organizing a site. She said that these can cause a problem with the overall structure of the course, causing students to learn only a fraction of the material on the syllabus because of time wasted on resolving these issues.

C: Integration. P2, P3 and P4 see integration as a problem that can occur when organizing web-based statistics learning material. P2's perception is that linearity does not exist while P3's and P4's experiences reveal that it is difficult to manage the interplay between subjects and emphasize the need for natural transitions.

> A lot of textbooks come with CDs inside, so in some sense you have this system in place with the book. I'm not completely sure how it should be organized. There should be a clear topic that is defined…topic one, topic two, topic three, etc…because linearity doesn't necessarily exist. (P2)

> When organizing web-based introduction to statistics learning materials I often have difficulties managing the interplay between the different topics. I can have materials that are related to our descriptive statistics or materials that are related to probability but they often times seem very disjointed and they seem very distinct from one another and one of the things that I like is to try and play up the interplay between them a little bit more and getting the materials really to reflect the interaction that we have between probability and inference, regression and descriptive statistics, and how they're all coming together. (P3)

> [There] should be a natural flow in terms of how a statistics course is taught. You begin with the introductory material, which is descriptive statistics. Then, [you] transition into the inferential statistics to make a bridge. As a result, a bridge between descriptive and inferential happens. That's the overall framework that should be done because the descriptive writing leads nicely into the inferential statistics. And then within the inferential the main things that you want are the subtopics of hypothesis testing, such as prediction of where these population parameters are, so that should be sort of like subdivided very carefully. (P4)

Compilation

Questionnaire item 6 asked, "In your experiences as a teacher what problems arise in the compilation of web-based introduction to statistics learning material? If you do not have experiences in the compilation of web-based material how do you think it should be compiled?" Interviewees responded with four problem areas that can arise in the compilation of web-based introduction to statistics learning material:

A. Course Structure
B. Attention
C. Consistency
D. Integration

A: Course Structure. Participants spoke of several problems that can potentially occur with the compilation of web-based statistics learning material. P1 discussed how materials need to be in sequential order to follow the course syllabus.

> You need to have materials in sequential order, such that it goes along with a syllabus. It makes sense to go from something easy to something more challenging. Courses are designed this way with a purpose. You build on the fundamentals in order to teach your students an entire subject or concept.

P1 believes that materials need to follow the syllabus because a syllabus provides a vision and functions as the course plan. Having web-based material follow its chronological format helps students all remain on the same page.

B: Attention. P1 was also concerned with the potential problem of the availability of web-based material making it difficult for some students to focus their attention on important classroom activities.

> There's also the issue of, if you let them use the technology in the classroom how do you grab their attention and engage them when you are doing something on the board and have to make that segue? I'm a firm believer that you should have one funny joke or one funny application of the topic for each day so that it's easy to

> draw them in. One day I chose the cartoon Homer Simpson. It doesn't matter what it is as long as it relates to the material somewhat.

P1 demonstrates how she develops approaches to maximize student engagement. She tries to provide a balance between instructional methods and approaches and providing real life connections through humor.

C: Consistency. P3 and P4 agree that consistency in notation is extremely important when compiling a web-based introduction to statistics learning material.

> A lot of textbooks, stats textbooks, sometimes have different notation or different terms that are used that sometimes can be inconsistent. Consistency is the biggest thing I would say for those who find statistics a little bit difficult. I've taught different stats classes before that have different terms that they use. Some use qualitative versus categorical for data, some use different symbols. But one example is population proportion, either being π or P. Consistency with notation is important because it's something that students already tend to have a problem with. I think that consistency would help student really see the connection between different materials for APIS. (P3)

> I notice that when you look at the different authors, different textbooks sometimes there's a lot of inconsistency between you and how certain concepts are being presented to you. One example is when you try to find out why something is said. There are certain authors focusing on using standard deviation while others want to use many resistant measures and sometimes there is overlap. At other times those books don't have some conformity in terms of having a single procedure, so you just keep going with what information you want to include and what information you want to keep out. (P4)

P3 and P4 believe that disambiguation in the compilation of web-based statistics learning material can confuse and disengage students. It's important to be consistent with notation and course content.

D: Integration. P2 and P3 raise the subject of integration as a potential problem.

> In my experiences as a teacher, I guess it becomes a matter of there's a variety of different places you can go and where do I want to go within my own course? There's a series of applets that I happen to use that were designed by a group of authors, but if I wanted a random number generator I would need to go to some other websites and unite it. There are things that are sort of all over the place and its difficult trying to bring them together. You guess admittedly. It would be wonderful if there was something there that was all in one spot and they were

> there together. And how should it be compiled? That's probably above my pay grade. (P2)
>
> I think it's just as important to keep the thematic ties between the topics as they go. We don't want one set of materials to approach a topic in one way and then have a completely different set of materials that are supposed to follow on with that approach from a different direction. (P3)

P2 emphasized the need for APIS because it is difficult to link material from various websites. However, he did not know how such a website should be compiled. P3 stressed the need for thematic ties between the subject matter.

Research Question 2: Areas of Statistics Appropriate for APIS

Question 2 asked, "What areas of statistics are particularly appropriate for APIS?" In order to answer this question, the four study participants replied to questionnaire item 7: "In your opinion and based on your experiences, what areas of statistics would be appropriate for APIS? [Description of APIS – a loosely organized, highly redundant collection, in various digital forms, of explanations, demonstrations, simulations, interactive exercises, problems, examples, elaborations, integrative expositions, as well as a deep, searchable information base (Rothkopf, 2009.] Examples will be provided." Participants' responses to this questionnaire item will be analyzed individually.

Pedagogical Concerns

Participants responded with two pedagogical issues, specifically:

A. Mastery

B. Content Uniformity

Mastery. Participants talked about the areas of statistics that they considered appropriate for APIS. P2 was concerned about mastery.

> Simulations may be a little bit harder to try to demonstrate and then try to get a bigger idea across. So trying to use simulations to get across the ideas of inference, where does it come from, that might be more complicated and I would wonder if they could; if that could be made successful.

P2 is questioning the effectiveness of using simulation to teach the idea of inference, hence his concern of mastery.

Content Uniformity. All participants felt that there are variations of content categories within statistics, making it an arduous task for students to understand the interrelationship among subjects.

> In my opinion there are areas of statistics that are appropriate.… [L]et's list them: normal distribution, regression, confidence intervals, probability, descriptive statistics and inference. I talk a little bit about things like the lottery, the gaming system, the casino and blackjack. A lot of people nowadays have played online, so I think you have to be careful how you approach the subject sometimes. But I think if you do it in the right way it still can be very engaging to the student and then you have their attention. (P1)

> For appropriate possibilities within APIS certainly I would imagine that anything dealing with introductory descriptive statistics would be appropriate. Simulations may be a little bit harder to try to demonstrate and then try to get a bigger idea across. So trying to use simulations to get across the ideas of inference, such as, where does it come from, might be more complicated and I would wonder if that could be made successful. Areas of statistics: inference, regression, descriptive statistics, and distribution. I would recommend to omit probability, or to do very little. (P2)

> I would probably put a little more of an emphasis on the probability and inference for something like APIS and definitely less of an emphasis on the design of the studies because that's something I feel we couldn't use. Unless, you wanted to look at examples of different studies like a collection of different statistical studies, and then use it like exercise sets because there are more materials there. Otherwise, I feel like it should be more geared towards probability and inference, especially. (P3)

> There are a lot of those reference materials, such as, tables of normal distribution. You see those graphs and those numbers. You master the connection between the distribution value and the probability value that you want to test your parameter. There are traditional repositories of all these different distributions out there. Do you have normal distribution or does it look like the chi-square distribution? When you start to look at getting hypothesis testing or normal distribution and the foundation is there, what you want is to

> add those things as well, because the similarities and differences begin the discussion…Only the averages that students care about—mean, median and mode in descriptive statistics are very important. The introduction to probability needs to be there, because again, just in order to make the bridge happen to go over inferential [statistics] and have those basic ideas of the likely events need to be established. The rules of probability, such as the addition rule and multiplication rule are very important as well as the basic counting principles that need to be applied to the binomial distribution. Creating the best line, seeing strong correlations, and also looking at different shapes of regression models and maybe start with a linear versus quadratic model would be helpful. We can hold off on multiple regressions. We can also forget about the binary distributions outside binary data sets. We can start the regression analysis with linear and then bridge them to other shapes such as quadratic to see what the best-fit model is using the coefficient of determination to see which of these models fits best to reduce the error of the predictions. Confidence interval and hypothesis testing, such as, the 2-sample Z test and 2-sample T test and the Goodness of Fit test should definitely be on there. (P4)

Although all participants agree that there is a lack of uniformity between subjects, P1, P3 and P4 want to see an emphasis on descriptive statistics, distributions (with a strong emphasis on normal distribution), probability, inference, confidence intervals and regression. P2, would like to see all areas of statistics included, except for probability. Harmonizing content uniformity allows students to understand statistical subjects in sequences that are properly scaffolded.

Research Question 3: Professionals' Reaction to APIS

Question 3 asked, "How do professionals involved in teaching statistics react to the web-based material?" In order to answer this question, participants were asked the following question: Questionnaire item 8: "How would you react as a teacher to teaching statistics based on utilizing assistance of web-based material such as could be found on APIS?" Participants' responses to this questionnaire item will be analyzed separately.

Reactions

Participants addressed how they would react as a teacher of statistics based on using the assistance of web-based material such as could be found on APIS, specifically:

A. Different Perspective

B. Accessibility of Resources

Different Perspective. P2 explained the importance of having students hear a different perspective in the classroom.

> While I might have my way of presenting [topics] in class, sometimes a student needs a second voice to hear from. I'm presuming, videos or something of that sort would be presented there. I would not want a single person doing all of them because I might explain something beautifully for student X, but student Y looks at me like I have three heads. They need to hear it from a different voice, from a different person. It is one of the reasons that if I was ever going to write a textbook,… I would not use my own textbook in my class because [it] would have me coming through and then the student would also have me in class. They would be getting the same voice twice. It would be important to have different voices so that you deal with the fact that there are different learning styles for students.

P2 believes students need to hear a different perspective in the classroom because it helps reach students with different learning styles and they would be able to understand or solve problems with alternative approaches. He fortifies his argument by stating that he would not have his class use his textbook if he were the author. APIS would be designed by a group of content experts to ensure a diversity of approach.

Accessibility of Resources. P1, P3, and P4 all talked about how APIS would be a convenient resource. P1 spoke about how she would welcome this new technology into her classroom.

> As a teacher, I think I would enjoy it and I would look forward to it. I think this is exactly where we are in 2015. We need to use technology to make teaching more relevant, more hands-on and interesting so that students understand really how it does affect their future careers and the world around them in general. I think it would be great to have this at

your fingertips and be able to just go to a link or to a hyperlink whatever it is to just bring up an appropriate resource. (P1)

I actually enjoy teaching with the web-based material. I find having these sorts of resources a lot of times makes me think about it in a way that I might not necessarily have originally. For instance, there are simulator applets that you can use to demonstrate the construction of normal distribution for students. It is not a way that I necessarily would've approached it. I would've looked at it a lot more in the way that I used to. Before I started using these, I was just going straight through, here is the normal distribution, here's a sampling distribution, here's how it comes about, and just talking about more in a theoretical sense. Now, I can approach it in a more visual one, and say to my students okay, this is how we are getting the sampling distribution, this is what the idea of the sampling distribution is, and I think it's a bit clearer this way than if I had just approached it from the more theoretical standpoint. So I like using the web resources in as many different ways I can. (P3)

I would very much support [APIS]. Just to have a repository directing students to attend the unit would be beneficial. Obviously our classrooms are all very tech-ready now, so you just pull that up and there could be many sample problems and several situations that you can easily refer to instead of having to solely rely on textbooks from publishers. To provide things in this repository that are independent of the textbook is very helpful. Logging onto the site from anywhere to access these major materials either in your office or in the classroom (*sic*). The accessibility would be very nice to have available to students and teachers so they can access it on their own. I would very much be in favor of this. (P4)

All survey participants responded positively to this new technology. P1, P2, P3 and P4 saw this as an easily accessible tool intended to help students and teachers tackle problems in a different way.

Research Question 4: Pedagogical and Practical Changes

Question 4 asked, "What are the pedagogical and practical changes that elementary statistics teachers need to undertake in order to enhance the use of web-based, self-access elementary statistics material to support the learning of the target group?" In order to answer this question, survey participants responded to two questionnaire items. Questionnaire item 9: "What are the pedagogical changes that Introduction to Statistics teachers would need to undertake in order to enhance the use of web-based self-access Introduction to Statistics material of your students?" Questionnaire item 10: "What are the practical changes that Introduction to Statistics teachers would need to undertake in order to enhance the use of web-based self-access Introduction to Statistics material of your students?" Participants' responses to the two questionnaire items will be analyzed separately.

Pedagogical Changes

The responses involving pedagogical changes to introductory statistics teachers would need to undertake in order to enhance the use of web-based, self-access introductory statistics material fell into five categories:

A. Teaching Methods
B. Use of the Web
C. Student Knowledge
D. Real World Application
E. Transition Period

Teaching Methods. P1 spoke about the importance of inventing new teaching styles to get through to all students and the importance of embracing new teaching techniques that move away from the old textbook-only teaching method. P3 and P4 talked about how teachers would not dominate the classroom with APIS. P3 feels that classroom environments are becoming more student-centric, while P4 sees a shift from teacher to technology.

> Teachers I know at colleges and universities are a mix of older and younger faculty. I'm kind of in the middle, I guess. I embrace both the old and new methods of teaching. Textbooks are good for reference material. I use a textbook as a reference in my classes, regardless. I think it is a sentimental change for faculty because they have to change from being textbook people and doing things by rote memory rather than… move over to technology each day. It is a bit of a different approach. Anything that makes people come to class, so that your class will be full is a good thing. Students know that today there will be something funny, tomorrow will be research, the next day it's something that you got

> off the website or Facebook or from the news. I used to do that a lot and I think it's a good method as long as it's kind of relevant. This way it applies to everyone. (P1)

> I would probably want to move a little bit away from the traditional lecture standpoint of the teacher being up in the front and then saying these are the things that were are going to be looking at, these are the ways that we use them, going forward. We are moving more towards an exploratory data set up where you have students participating more in class exercises or projects and kind of structuring a class around that. I think students would probably benefit a lot from everyone's resources [being] available. (P3)

> A service shift will be very well worth it. The teacher can't dominate the conversation now. So it shows you exactly how we can use this technology to get that same information that we might struggle with before. Using this form is a way we've done it but going ahead and applying [it] in different ways that are more seamless are worth a try. (P4)

P1 felt that the transition from old to new teaching methods was a change that benefited the students. She incorporates technology in her course curriculum that interests students as long as it is applicable to the day's subject. P3 believes that a student-centric environment has a positive effect on student involvement with course content and motivation. Educators are finding different ways of using class time. Introverted students are finding ways to participate in class discussion. P4 welcomes the transition from teacher to technology. This pedagogical change will allow teachers to use APIS so that they can explain concepts in a more effective manner.

Use of the Web. P2 felt that a transformation caused by randomization-based techniques is a pedagogical change that is slowly gaining popularity.

> There is starting to be a major overhaul in Intro to Statistics courses in general with randomization based techniques coming through and being used in great detail. I have started using a lot of it myself. Other instructors that I work with are slowly starting to do it. It is not going to happen overnight. It will probably take the better part of a decade or so but I rather suspect that the intro to stats course that most people think of today will not exist in its current form 10 years from now for a variety of reasons. One, technology has allowed us to be able to do simulation very quickly, which would not have been available even 10 years ago.

P2 felt that randomization-based techniques are a pedagogical change that saves time with its ease and accessibility. He, along with many fellow colleagues, has embraced this new teaching method.

Student Knowledge. P2 also stated that students entering college have more statistical knowledge.

> College students are now entering with more statistical knowledge – at least introductory statistical knowledge – than what they did 10 years ago. There are so many kids who have taken AP exams or they took a fourth year of math in high school so they already know what (mean) is, they already know what a (mode) is, they already know about standard deviation. Spending time on that in an intro stats course in college seems like a waste, so those changes would meet those pedagogical changes which are naturally happening and I would imagine a website of this sort would need and would want to be ready for that kind of change as well.

P2 felt that many of today's introductory statistics students understand the fundamentals of statistics and how those designing APIS would need to be aware of this natural pedagogical change. There are more advanced students and APIS would need to accommodate them.

Real World Application. P3 talked about having his class geared toward application rather than theory.

> Shifting the direction of application over the pure mathematics behind it, which is a trend (*sic*). I actually already am seeing for the most part there are lot of statisticians that I've heard from or read articles from online that suggest automating a lot of the computations and web-based tools are really great for doing that. Things like if your computing a P value (probability value) you don't want to necessarily compute the test statistic then refer to the table and kind of go through all that process because then the purpose tends to get a little bit lost. So, I think making that sort of shift away from using formulas and using data tables to automating a lot of the computations and focusing more on the mechanics and the applications would probably be one of the biggest pedagogical changes that would help to make use of a lot of these web-based resources because some of the tools are really geared towards that automation and demonstration of the mechanics in order to use them for the applications.

P3 felt that there was no reason to generate answers manually if they can easily be computed with online programs. If teachers can have the computer crunch the numbers they can concentrate on the empirical side and focus on application.

Transition Period. P4 felt that a transition period or trial is necessary to understand how APIS works, so that teachers can see how they can use and incorporate the formulas, demonstrations and examples into course curriculum.

> The one transition that the instructor would have to do is maybe after realizing the need to spend as much time focusing on all the formulas and having to drive that through the process and maybe his initial expectations, they would need that trial transition and say now here's the place where we can compile or utilize these formulas in a very easy way so you can apply that to various situations.

Practical Changes

Questionnaire item 10 asked, **"**What are the practical changes that Introduction to Statistics teachers would need to undertake in order to enhance the use of web-based, self-access Introduction to Statistics material of your students?" P1 through P4 identified three categories of changes introductory statistics teachers would need to undertake in order to enhance the use of web-based, self-access Introduction to Statistics material, specifically:

A. Instruction
B. Instructor mastery
C. Mentoring

Instruction. P4 spoke about the amount of technology instructors want include in their instruction.

> I think this really depends on the kind of instructor… because some of the traditional instructors might want to do something like avoid some technologies. Some [others] are just very technology heavy so it's a delicate balance to try to see how much technology you want to integrate into your instruction. I think that the teacher must recognize that this now can all be done in a very efficient way and will be able to do rigorous analysis to

connect to what's happening in real world situations. But it's a matter of embracing everything that is fully out there, and say, "Okay, this is the APIS that is fully available, not no let's keep on using this bigoted consistent thing." Because as involved as this is, in the end, in any classroom setting, the instructor always looks twice to see if [technology] can have some impactful changes to a student. It consistently uses the amount of integrated material into the course lesson plan and shows how other teachers teach…

P4 sees integration of technology as a delicate situation. Although it is a teacher's personal choice to decide how little or how much they want to incorporate APIS in their lesson plan, they cannot be intolerant to change.

Instructor Mastery. P2 saw instructor mastery of the APIS website as a practical change that introductory statistics teachers would need to undertake.

> I would imagine the practical change would be that the instructors need to just get used to it. The first time I used My Math Lab within a course of a Pearson product, I just had to get used to working with My Math Lab. I would imagine from a practical perspective that if there is suddenly a website that I'm now going to [use], that I would be expecting or having my students utilize it heavily. I better be able to know where everything is, so that the practical thing is trying to make sure that I can guide them through [the website].

P2 felt that instructors need to meet professional standards and learn to navigate APIS. It is incumbent that teachers get proper training so that they can guide their students.

Mentoring. P3 talked about the need of mentoring as opposed to lecturing.

> If you have all those web resources available, you can introduces students to the resources and have them kind of work through them. Some like the interactive exercises that were mentioned. Having them work through those and then have the instructor take more of almost a mentor role, walking around answering questions, giving guidance throughout the class. I don't know if there's anything specifically that would absolutely need to overall change like a very big paradigm shift, but in general, I think just changing the classroom set-up away from the traditional lecture model would probably be one of the biggest, most beneficial practical things.

P3 discussed how a shift in the classroom structure would be a practical change teachers would need to undertake. Having the teacher's role move towards being a mentor instead of a lecturer would give students the chance to work through problems on their own and ask for assistance if needed. Teachers' roles are shifting from owners of information to facilitators and guides to learning. Different approaches to teaching are being used in the same class. Raw data tables are in Appendix B.

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter contains a summary of the study and a discussion of its findings in three steps. First, the need, purpose, and procedures will be identified and discussed. Second, there will be a reflection on the findings discovered in Chapter IV from the research and answers to the four research questions. Last, the chapter will be concluded by offering advice to professional educators and administrators and making recommendations for further research.

Summary

The United States prides itself on being a high achiever in technology; however, one major problem is linking this advanced technology to classroom practice. Our classrooms do not prepare students for proficiency in the advanced level of mathematics and scientific competency that many jobs require (Rothkopf, 2009, p. 3; PISA, 2004). These concerns have created large-scale efforts to improve student achievements, particularly in courses that are taught year after year throughout the United States, such as Introductory Statistics at the undergraduate level.

For the past two decades, the statistics-education community has been actively seeking reform, with a focus on college-level introductory statistics (Hassad, 2014). In 2005, The Guidelines for Assessment and Instruction in Statistics Education (GAISE) report provided six recommendations to encourage statistics instructors to modernize introductory statistics courses; one recommendation was an emphasis on technology. This study investigated the application of web-based pedagogy for teachers of elementary statistics using *A Pedagogical Information System* (APIS) that was originally designed by Dr. Ernst Rothkopf, Professor Emeritus of

Columbia Teachers College, in order to explore ways that teachers can enhance instruction via technology in the classroom. “APIS is a loosely organized, highly redundant collection, in various digital forms, of explanations, demonstrations, simulations, interactive exercises, problems, examples, elaborations, integrative expositions, and a deep, searchable information base” (Rothkopf, 2009, p.2). This information system would provide new opportunities for practical teacher education, given the limited literatures on statistics pedagogy and web-based teaching and learning. My research is opening up a new area of study. My study is exploratory and therefore suggestive.

The purpose of the study was to examine issues of efficacy, efficiency, and effectiveness of the use of Internet websites in the instruction of Introductory Statistics at the college level. “Efficacy” includes perceptions of competence and confidence of instructors of introductory statistics in their abilities to use the Internet as a teaching device. “Efficiency” relates to the improvement of instructional time that web-based resources can provide introductory statistics instructors. “Effectiveness” refers to the ability of web-based resources to enhance the learning process so that students learn statistical concepts more thoroughly and completely than they would without web-based sources.

This study sought answers to the following questions:

1) What problems (pedagogical and practical) arise in the design, organization, and compilation of web-based elementary statistics learning material?
2) What areas of statistics are particularly appropriate for APIS?
3) How do professionals involved in teaching statistics react to the web-based material?

4) What are the pedagogical and practical changes that elementary statistics teachers need to undertake in order to enhance the use of web-based, self-access, elementary-statistics material to support the learning of the target group?

The participants for this study were four instructors of Introductory Statistics courses at the undergraduate level in the same state system of higher education in a Northeastern state of the United States. These educators were interviewed individually for approximately 60 minutes each in a semi-structured format in which they discussed their experiences and perceptions about using Internet sources for instruction of students in Introductory Statistics.

The design of the study was qualitative and used a phenomenological interpretive method. There are multiple approaches for an Interpretative Phenomenological Analysis (IPA), which gives the analyst the freedom to understand the participants' experiences by using different processes of analysis. The research questions were answered using the set of steps for Interpretative Phenomenological Analysis (IPA) given by Smith et al. (2009).

Conclusion

Research Question One: What problems (pedagogical and practical) arise in the design, organization, and compilation of web-based elementary statistics learning material?

This research question was broken down into three questionnaire items that were posed to interview participants. Responses unanimously suggest the greatest problems that could arise in the design of web-based introduction to elementary statistics learning material was the difficulty of having the correct resources and having them easily accessible. Also mentioned were the challenges of making sure the content is sufficient, organized, and readily available, providing teachers and students with proper software training, and having challenges resulting from a variety of teaching methods.

Results show participants found that having students with different learning styles, having to allocate time to deal with details, and having difficulty managing the interplay between topics as being key problems that could arise in the organization of web-based introduction to elementary statistics learning material. Participants saw the interplay among topics as the biggest concern when organizing web-based statistics learning material. They thought it was important to have students see parallels among topics so that they could understand the framework.

Respondents stated that the key problems that could arise in the compilation of web-based introduction to statistics learning material are: needing materials to be in sequential order to follow syllabi; retaining student attention to the lecture as they navigate the web; consistency of terms and symbols; and integration of material. Teachers are flooded with the resources and web-based pedagogical/learning supports available and are left to decipher how to merge these resources into their preexisting pedagogy (Kelly & Orr, 2003; Wallace, 2004).

Research Question Two: What areas of statistics are particularly appropriate for APIS?

Participants answered this question by bringing up two pedagogical concerns—content uniformity and mastery. They thought that there were numerous variations of content categories within statistics, making it difficult for students to understand the interrelationship among subjects. Although all participants agreed that there is a lack of uniformity among subjects, most want to see an emphasis on descriptive statistics, distributions (with a strong emphasis on normal distribution), probability, inference, confidence intervals, and regression. One participant would like to see all areas of statistics included, except for probability. This participant was also concerned about mastery.

Research Question Three: How do professionals involved in teaching statistics react to the web-based material?

There was an overwhelming positive response by most participants, who welcomed APIS and its convenient 24-hour accessibility. The responses were that APIS was cutting-edge, innovative, and beneficial in this tech-ready world. One participant also talked about the importance of having his students hear a different voice in the classroom. APIS would be designed by a group of content experts to ensure a diversity of approaches.

Research Question Four: What are the pedagogical and practical changes that elementary statistics teachers need to undertake in order to enhance the use of web-based, self-access, elementary-statistics material to support the learning of the target group?

This research question was broken down into two questionnaire items and posed to interview participants. The pedagogical changes that elementary statistics teachers would need to undertake fell into five categories. First, teaching methods—embracing new teaching techniques that move away from the old textbook-only teaching method, and finding new teaching styles to address a variety of student learning styles. With APIS, teachers would no longer dominate the classroom. One participant talked about the way classrooms are becoming more student-centric, while another participant saw a shift from teacher to technology. Second, the use of the web—a transformation caused by randomization-based techniques is a pedagogical change that is slowly gaining popularity. Third, student knowledge—students entering college having more statistical knowledge. Students are more advanced prior to entering post-secondary school. Four, real-world application—the class instruction would be geared toward application rather than theory, due to the automation and demonstration of the mechanics, in order to use the mechanics for application. Lastly, transition period—the time needed for a teacher's pilot test and seeing how the teacher can incorporate APIS into his or her course curriculum.

The practical changes that elementary statistics teachers would need to undertake in order to enhance the use of web-based self-access elementary statistics material to support the learning of the target group fell into three categories. First, instruction—instructors need to decide the level of technology they will incorporate into their course instruction. Second, instructor mastery of the APIS website—proper training and meeting professional standards are necessary to navigate APIS so that instructors in turn can guide their students effectively. Third, mentoring—the need to have the teacher move towards being a mentor as opposed to a lecturer.

Furthermore, participants were asked the following additional questions not based on the original research questions: "In your experiences, what is the greatest pedagogical challenge in teaching students Introduction to Statistics? In your experiences, what are the greatest pedagogical opportunities in teaching Introduction to Statistics to your students? In your experiences, what is the greatest practical challenge in teaching Introduction to Statistics to your students? What are the Best Practices of your colleagues when teaching Introduction to Statistics to undergraduate students?" These questions are purely exploratory and were asked with no preconceived expectations.

Interviewees responded with the four biggest pedagogical challenges in teaching statistics to Introduction to Statistics students, specifically: the difficulty of having students of different math backgrounds and getting all students to the same level of proficiency;, developing math problems that relate to students' fields of study to engage those no longer paying attention in class; building instructor mastery; and integrating different aspects of statistical analysis.

Participants talked about two main pedagogical opportunities in teaching Introduction to Statistics to their students, specifically: being given the opportunity to teach sampling distribution and connecting course content to real-world scenarios.

Participants discussed the seven practical challenges in teaching Introduction to Statistics to their students, specifically: focusing on relevant information in a world of abundant information; having fundamental skills (reading skills, understanding concepts—being able to tell students when they can use a particular concept would be a huge accomplishment); finding a connection between course content and students' fields/areas of interest; having access to technology; dealing with budgetary problems in schools; failing to meeting student expectations of what is required to understand material; and having difficulty accepting more than one answer to a problem.

Interviewees discussed the Best Practices of their colleagues when teaching Introduction to Statistics. One participant stated that he and his colleagues talk about concerns as they arise, but they do not formally sit down and have discussions on Best Practices. The others, however, discussed the following Best Practices methods their colleagues use when teaching Introduction to Statistics: differentiating instruction to meet students' needs; having a balanced curriculum; and providing active learning opportunities for students.

Recommendations

Although a sample size of 3-6 participants is deemed sufficient for the development of "meaningful points" (Smith et al., 2009, p.51), one recommendation to improve this study would be to increase the number of participants and to include adjunct professors who use statistics at work. This would provide additional research that would help strengthen existing findings or find other topics of exploration. A recommendation to further research this study would be to step outside of APIS and investigate the pedagogical/practical challenges in teaching Introduction to Statistics to undergraduate students, the practical opportunities in teaching introductory statistics to undergraduate students, and the best practices of instructors' colleagues when teaching introductory statistics to their students. The questions in this study were posed to interview participants as exploratory questions. The results of this study are preliminary, which can be explored further for additional research.

Another topic for subsequent research is the effect of the application of web-based technologies such as APIS on the learning of statistical principles. Comparisons of courses with textbook-only instruction versus courses with integration of the web could be conducted. Variables such as learning of content, student satisfaction, retention, and knowledge could be studied and evaluated.

Subsequent researchers might consider evaluating the effectiveness of educational resources on statistics websites. According to Ooms and Garfield (2008, p. 2), "An evaluation model that could be used to evaluate and improve existing educational resources is needed." The number of online resources designed to enhance the learning and teaching of statistics has increased (Chance et al., 2007). Future researchers could design a model to evaluate the web content of educational resources—data collected from content experts—to determine if the goals and intentions of the statistical websites are stated clearly.

Redefining undergraduate education in statistics has been and continues to be an important topic of research. Although this study provides additional background information related to the teaching and learning of introductory statistics at the undergraduate level, statistics-education literature lacks studies related to exploring teachers' experiences in an introductory statistics course at the undergraduate level. As a teacher of mathematics and statistics, I believe that understanding how teachers react to perceptions and experiences helps me be a better teacher to my students.

This study demonstrates to professional educators that their peers welcome incorporating technology in their classrooms. It is an additional tool that can be utilized, along with a textbook, to connect Introduction to Statistics with real-world application and demonstration, engage students by piquing their interest and understanding, and serve as a resource that instructors can use to improve their teaching styles and techniques. By incorporating a technological resource such as APIS, teachers would give their students taking Introductory Statistics the tools available to excel, and the teachers would have an instructional benefit.

The major implication of the findings of the study for educational practitioners, especially instructors of introductory statistics, is that the profession is on the verge of a revolution brought about by the Internet. Already, many resources are available that can be used by introductory statistics instructors to: illustrate statistical processes; pose problems that require statistical solutions; provide databases that can be used for analytical purposes; and calculate various descriptive and inferential statistics. It is just a matter of time until websites emerge that combine these and other processes into instructional packages that provide interactions with students as they learn basic statistical concepts.

So what are the implications of this study for instruction in introductory statistics? First, as some study participants have mentioned, a dramatic change in the role of the instructor is coming. The Internet is much better and more sophisticated in the transmission of statistical knowledge than even the best instructors. This means that the introductory statistics instructor will be less a dispenser of statistical information and more a mentor of students as they explore statistical concepts on the web. The Instructor's role will involve: helping students solve problems; providing assistance when students are confused; making suggestions of possible research topics to explore using statistics; providing enrichment materials; evaluating student progress; and so forth.

In addition, the Internet can provide students with practical applications of statistics from a variety of fields. This might include such topics as: prediction of sales based upon prior data; correlation of sports teams' winning percentages with the quality of prior recruiting years; interpretation of political preferences from polls; examination of disease "hotspots"; and so forth. The implications of the findings of the study are that learning statistics is going to be less abstract and learned more through the application of knowledge. Students will still have to learn the basic concepts, such as the mean and standard deviation, but then they will also have to learn how these concepts can be used to solve common problems. In such cases, the instructor will be supervising student projects and evaluating them.

Will the Internet replace instructors of introductory statistics? The research suggests that this is not the case. The findings suggest that introductory statistics instructors will actually be more intimately involved in the learning process than when they were standing in front of the class writing formulas on chalkboards. The role of the Internet in Introduction to Statistics courses should not be to replace instructors and/or to increase class sizes, but to provide a supportive environment in which students can properly learn statistical concepts and apply them to a wide range of problems.

BIBLIOGRAPHY

Aberson, C. L., Berger, D. E., Healy, M. R., Kyle, D. J., & Romero, V. L. (2000). Evaluation of an interactive tutorial for teaching the central limit theorem. *Teaching of Psychology*, *27*(4), 289-291.

American Statistical Association (ASA). (2005).GAISE college report. Retrieved from http://www.amstat.org/education/gaise/GaiseCollege_full.pdf

Baraniuk, R. G. & Burrus, C. S. (2008). Global warming toward open educational resources: Seeking to realize the potential for significantly improving and advancing the world's standard of education. *Communications of the ACM, 51*(9): 30-32.

Becker, B. J. (1996). A look at the literature (and other resources) on teaching statistics. *Journal of Educational and Behavioral Statistics*, *21*(1): 71-90.

Bliwise, N. G. (2005). Web-based tutorials for teaching introductory statistics. *Journal of Educational Computing Research*, *33*(3), 309-325.

Branch, R. M., Kim, D., & Koenecke, L. (1999). Evaluating online educational materials for use in instruction. ERIC Digest. Retrieved from http://www.pbs.org/teacherline/courses/math185/eric_evaluating_materials.htm?cc=tlredi

Chance, B. Ben-Zvi, D. Garfield, J. and Medina, E. (2007). The Role of Technology in Improving Student Learning of Statistics. *Technology Innovations in Statistics Education, 1*(1): 1-26.

Cobb, G. (1992). Teaching statistics. *Heeding the call for change: Suggestions for curricular action*, *22*, 3-43.

Cobb, G. W. (1993). Reconsidering statistics education: A national science foundation conference. *Journal of Statistics Education*, *1*(1), 25.

Cobb, G. W. (2007). The introductory statistics course: a Ptolemaic curriculum? *Technology Innovations in Statistics Education*, *1*(1).

Cobb, G. W. (2015). Mere renovation is too little too late: We need to rethink our undergraduate curriculum from the ground up. Retrieved from *arXiv preprint arXiv:1507.05346*.

Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches* (2nd ed.). Thousand Oaks, CA: Sage.

Dallal, G. E. (1990). Statistical computing packages: Dare we abandon their teaching to others? *The American Statistician*, *44*(4), 265-266.

Dinov, I. & Sanchez, J. (2006). Assessment of the pedagogical utilization of the statistics online computational resource in introductory probability courses: A quasi-experiment. *Department of Statistics, UCLA. Department of Statistics Papers.* Retrieved from http://socr.ucla.edu/docs/Dinov_Sanchez_ICOTS7_2006.pdf

Engelbrecht, J. & Harding, A. (2005). Teaching undergraduate mathematics on the Internet: Part 2: Attributes and possibilities. *Educational Studies in Mathematics, 58*: 253-276.

Frey, J.(1989). Technology and mathematics education: A survey developments and important problems. *Educational Studies in Mathematics*, *20*(3), 237-272.

Fry, E. B. (2014). Introductory statistics instructors' practices and beliefs regarding technology and pedagogy. In *9th International Conference on Teaching Statistics (ICOTS-9), Flagstaff, Arizona, USA*. Retrieved from http://icots.info/9/proceedings/pdfs/ICOTS9_C202_FRY.pdf

Garfield, J.B. (2000). An evaluation of the impact of statistics reform: Final report for National Science Foundation project REC-9732404.

Garfield, J., Hogg, B., Schau, C., & Whittinghill, D. (2002). First courses in statistical science: the status of educational reform efforts. *Journal of Statistics Education*,*10*(2), 456-467.

Garfield, J., Chance, B., & Snell, J. L. (2002). Technology in college statistics courses. In *The Teaching and Learning of Mathematics at University Level* (pp. 357-370). Springer: Netherlands.

GAISE College Report (2012). *Guidelines for Assessment and Instruction in Statistical Education (GAISE) College Report.* The American Statistical Association. Retrieved from http://www.amstat.orgg/education/gaise.

Hall, M. R., & Rowell, G. H. (2008). Introductory statistics education and the National Science Foundation. *Journal of Statistics Education*, *16*(2), 1-9.

Hassad, R.A. (2009). Reform-oriented teaching of introductory statistics in the health, social and behavioral sciences: Historical context and rationale. *International Journal of Social Sciences, 4(2).*

Hassad, R. A. (2010). Reform-oriented teaching of introductory statistics in the health, social and behavioral sciences-historical context and rationale. Retrieved from *arXiv preprint arXiv:1007.3207*.

Hassad, R. A. (2014). The status of reform in statistics education: A focus on the introductory course. Retrieved from http://iase-web.org/icots/9/proceedings/pdfs/ICOTS9_C196_HASSAD.pdf

Hogg, R. (1992). Report of workshop on statistics education. *Heeding the Call for Change: Suggestions for Curricular Action, MAA Notes*, *22*, 34-43.

Hyman, A. (2003). Twenty years of ListServ as an academic tool. *The Internet and higher education*, *6*(1), 17-24.

Kader, G. & Perry, M. (2002). A statistics course for elementary and middle school teachers. *ICOTS6*. Retrieved from http://iase-web.org/documents/papers/icots6/3i1_kade.pdf

Kelley, K. B., & Orr, G. J. (2003). Trends in distant student use of electronic resources: A survey. *College & Research Libraries*, *64*(3), 176-191.

Kuiper, S. R. (2010). Incorporating a research experience into an early undergraduate statistics course.. *Proceedings of ICOTS-8*, IASE. Retrieved from http://iase-web.org/documents/papers/icots8/ICOTS8_4G1_KUIPER.pdf

Lane, D. M., & Tang, Z. (2000). Effectiveness of simulation training on transfer of statistical concepts. *Journal of Educational Computing Research*, *22*(4), 383-396.

Lesser, L. M., & Groth, R. (2008). Technological pedagogical content knowledge in statistics. In *Electronic Proceedings of the Twentieth Annual International Conference on Technology in Collegiate Mathematics* (pp. 148-152). Retrieved from http://archives.math.utk.edu/ICTCM/i/20/S118.html

Loftsgaarden, D.O., & Watkins, A.E. (1998). Statistics teaching in colleges and universities: Courses, instructors, and degrees in fall 1995. *The American Statistician, 52(4),* 304-314.

Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States.* Mahwah, NJ: Lawrence Erlbaum Associates. Retrieved from http://www.ams.org/journals/notices/199908/rev-howe.pdf

Marshall, M.N. (1996). Sampling for qualitative research. *Family practice*, 13, pp. 522-525.

Mason, R. L. ASA: The First 160 Years. Retrieved from http://www.amstat.org/about/first160years.cfm

Mills, J. D. (2002). Using computer simulation methods to teach statistics: A review of the literature. *Journal of Statistics Education*, *10*(1), 1-20.

Moore, D. S. (1993). A generation of statistics education: An interview with Frederick Mosteller. *Journal of Statistics Education*, *1*(1), 1-22.

Moore, D. S. (1997). New pedagogy and new content: the case of statistics. *International Statistical Review*, *65*, 123-165.

Moore, D. S. (2005). Quality and relevance in the first statistics course. *International Statistical Review*, *73*(2), 205-206.

Moustakas, C. (1994). *Phenomenological research methods.* Thousand Oaks, CA: Sage.

National Science Foundation. About NSDL. *National Science Digital Library.* Retrieved from http://nsdl.org/about

Ooms, A., & Garfield, J. (2008). A model to evaluate online educational resources in statistics. *Technology Innovations in Statistics Education*, *2*(1), 1-17.

Pea, R.D. (1987). Cognitive technologies for mathematics education. In A.H. Schoenfeld (Ed.), *Cognitive science and mathematics education* (pp. 89-122). Hillsdale, NJ: Erlbaum.

Phillips, B. (2003). Overview of online teaching and internet resources for statistics education. In *Proceedings, IASE Satellite Conference on Statistics Education and the Internet, Berlin. Retrieved from www. stat. auckland. ac. nz/~ iase/publications. php*.

PISA (2004) *Learning for Tomorrow's World: First Results from PISA 2003.* Paris: OECD Publishing.

Rothkopf, E.Z. (2009). An immodest proposal: Pedagogic information supports for teachers. *The Teachers College Record, 111*(1), 164- 179.

Rubin, A. (2007). Much has changed; little has changed: Revisiting the role of technology in statistics education 1992-2007. *Technology Innovations in Statistics Education*, *1*(1),1-33.

Rubin, H.J. & Rubin, I.S. (2012). *Qualitative interviewing: The art of hearing data,* 3rd ed. Thousand Oaks, California: Sage.

Sanders, P. (1982). Phenomenology: A new way of viewing organizational research. *Academy of Management Review, 7(3),* 353-360.

Scheaffer, R. L. (1986). The quantitative literacy project. *Teaching Statistics*, *8*(2), 34-38.

Schenone-Stevens, M. C. (1999). Reflections from the classroom on the effects of computer-assisted instruction on the teaching learning process. Retrieved from http://eric.ed.gov/?id=ED437700

Shaughnessy, J.M. (2007). Research on statistics learning and reasoning. In F.K. Lester, Jr. (Ed.), *The Second handbook of research on mathematics teaching and learning* (pp.957-1009). Greenwich, CT: Information Age.

Smith, J., Flowers, P., & Larkin, (M. (2009). Interpretative Phenomenological Analysis: theory, method and research.

Symanzik, J. and Vukasinovic, N. (2003). Teaching Experiences with a Course on Web-Based Statistics, *The American Statistician, 57(1),* 46-50.

Tamim, R. M., Bernard, R. M., Borokhovski, E., Abrami, P. C., & Schmid, R. F. (2011). What forty years of research says about the impact of technology on learning a second-order meta-analysis and validation study. *Review of Educational Research*, *81*(1), 4-28.

Tishkovskaya, S. V., & Lancaster, G. A. (2014). The Use of Web Resources in Statistical Education. Retrieved from http://icots.info/9/proceedings/pdfs/ICOTS9_C173_TISHKOVSKAYA.pdf

Tishkovskaya, S., & Lancaster, G. A. (2010, July). Teaching strategies to promote statistical literacy: review and implementation. In *Proceedings of the 8th International Conference on Teaching Statistics, 11-16 July, Ljubljana, Slovenia*. Retrieved from http://iase-web.org/documents/papers/icots8/ICOTS8_C193_TISHKOVSKAY.pdf

Tishkovskaya, S., & Lancaster, G. A. (2012). Statistical education in the 21st century: a review of challenges, teaching innovations and strategies for reform. *Journal of Statistics Education*, *20*(2), 1-55.

Thisted, R. A., & Velleman, P. F. (1992). Computers and modern statistics. *Perspectives on Contemporary Statistics. MAA notes*, (21).

Wallace, R.M. (2004). A framework for understanding teaching with the Internet. *American educational research journal, 41(2),* 447-488.

Wang, Y. M. (2007). Internet uses in university courses. *International Journal on E-Learning*, *6*(2), 279-292.

Zieffler A , Park J, Garfield J , Delmars R, & Bjornsdottir, A. (2012). The statistics teaching inventory: A survey on statistics teachers' classroom practices and beliefs. *Journal of Statistical Education, 20*(1), 1-29. Retrieved from http://www.amstat.org/publications/jse/v20n1/zieffler.pdf

Zieffler, A., Garfield, J., Alt, S., Dupuis, D., Holleque, K., & Chang, B. (2008). What does research suggest about the teaching and learning of introductory statistics at the college level? A review of the literature. *Journal of Statistics Education*, *16*(2), 1-23.

APPENDIX A

Semi-Structured Interview Protocol

Appendix A

Interview Protocol

I. Discuss how their confidentially, right of refusal without retribution, and right to have access to the findings of the study will be guaranteed.

II. General demographic information including gender, degree etc……. will be collected.

III. Provide definition of Pedagogy vs practical

IV. Start of questions. A list of common topics in an Introduction to Statistics course will be provided.

1. Think of a time when you learned best practices from an experienced instructor of an Introduction to Statistics and describe that in as much detail as possible?

2. Why is an Introduction to Statistics course important to teach and included in your curriculum?

3. What are the greatest challenges to teaching students Introduction to Statistics in your class? (Note: this is a leading question to get them talking).

4. In your experiences as a teacher what problems arise in the design of web based Introduction to Statistics learning material? What problems could arise in the design of a web based elementary statistics learning material.

5. In your experiences as a teacher what problems arise in the organization of web based Introduction to statistics learning material? If you do not have experiences in organizing web based material how do you think it should be organized?

6. In your experiences as a teacher what problems arise in the compilation of web-based Introduction to statistics learning material? If you do not have experiences in the compilation of web based material how do you think it should be compiled?

Description of APIS - a loosely organized, highly redundant collection, in various digital forms, of explanations, demonstrations, simulations, interactive exercises, problems, examples, elaborations, integrative expositions, as well as a deep, searchable information base. (Rothkopf, 2009). Examples will be provided.

7. In your opinion and based on your experiences, what areas of statistics would be appropriate for APIS?

8. How would you react as a teacher to teaching statistics based on utilizing assistance of web based material such as could be found on APIS? (Note: This is a hypothetical question because the actual APIS website does not exist).

9. What are the pedagogical changes that Introduction to Statistics teachers would need to undertake in order to enhance the use of web-based self -access Introduction to statistics material of your students?

10. What are the practical changes that Introduction to Statistics teachers would need to undertake in order to enhance the use of web-based self- access Introduction to Statistics material of your students?

11. In your experiences what is the greatest pedagogical challenge in teaching students Introduction to Statistics?

12. In your experiences what are the greatest pedagogical opportunities in teaching Introduction to statistics to your students?

13. In your experiences what is the greatest practical challenge in teaching Introduction to statistics to your students?

14. What are the Best Practices of your colleagues when teaching Introduction to Statistics to undergraduate students?

15. What questions, if any, do you have for me at this time?

APPENDIX B

Analytical Tables

Appendix B: Analytical Tables

Table B.1: Responses for Interview Question 4

4. In your experiences as a teacher what problems arise in the design of web based Introduction to Statistics learning material? What problems could arise in the design of a web based elementary statistics learning material?				
Participant ID:	Topic 1: Content	Topic 2: Resources	Topic 3: Software Training	Topic 4: Teaching Methods
1		Finding the correct resources and having them easily accessible in the classroom as well as at home.		
2				Challenges resulting from a variety of teaching methods.
3		Having the right resources and support.	Lack of familiarity of software.	
4	Make sure content is sufficient, organized and readily available.			

Table B.2: Responses for Interview Question 5

5. In your experiences as a teacher what problems arise in the organization of web-based Introduction to Statistics learning material? If you do not have experiences in organizing web-based material how do you think it should be organized?			
Participant ID:	Topic 1: Learning Styles	Topic 2: Time	Topic 3: Integration
1	Students with different learning styles.	A lot of time needed to iron out details.	
2			Linearity between topics doesn't exist.
3			Difficult to manage interplay between topics.
4			Should have a natural flow to transition topics and bridge them together.

Table B.3: Responses for Interview Question 6

6. In your experiences as a teacher what problems arise in the compilation of web-based Introduction to statistics learning material? If you do not have experiences in the compilation of web-based material how do you think it should be compiled?				
Participant ID:	Topic 1: Course Structure	Topic 2: Attention	Topic 3: Consistency	Topic 4: Integration
1	Materials need to be in sequential order to follow syllabus.	Need to engage students and keep their attention on your lecture while they navigate repository of web based material.		
2				Importance of integration of material. Currently scattered information.
3			Consistency of terms and symbols.	Importance of integration of material.
4			Consistency between concepts and the way they are presented to you.	

Table B.4: Responses for Interview Question 7

Description of APIS – a loosely organized, highly redundant collection, in various digital forms of explanations, demonstrations, simulations, interactive exercises, problems, examples, elaborations, integrative expositions, as well as a deep, searchable information base. (Rothkopf, 2009). 7. In your opinion and based on your experiences, what areas of statistics would be appropriate for APIS?		
Participant ID:	Topic 1: Mastery	Topic 2: Content Uniformity
1		Emphasis on descriptive statistics, distribution, probability, inference, confidence intervals and regression.
2	Concern of mastery.	Emphasis on inference, regression, descriptive statistics, and distribution. Recommend little or no probability.
3		Emphasis on descriptive statistics, distribution, probability, inference, confidence intervals and regression.
4		Emphasis on descriptive statistics, distribution, probability, inference, confidence intervals and regression.

Table B.5: Responses for Interview Question 8

8. How would you react as a teacher to teaching statistics based on utilizing assistance of web-based material, such as could be found on APIS?		
Participant ID:	Topic 1: Different Perspective	Topic 2: Accessibility of Resources
1		Welcomes having access to resources at their fingertips.
2	Importance of different voices of opinion.	
3		Overall and complete approval of the resources.
4		a.) Repository independent of the textbook very helpful. B.) Students and Teachers have access to material 24/7.

Table B.6: Responses for Interview Question 9

9. What are the pedagogical changes that Introduction to Statistics teachers would need to undertake in order to enhance the use of web-based self-access Introduction to statistics material of your students?					
Participant I	Topic 1: Teaching Methods	Topic 2: Use of the web.	Topic 3: Student knowledge	Topic 4: Real World Application	Topic 5: Transition Period
1	a.) Come up with various teaching styles to get through to all students. b.) Move away from textbook style.				
2		Transformations caused by randomization-based techniques.	More advanced students from High School.		
3	Student-centric.			Geared toward application as opposed to theory.	
4	Teachers don't dominate conversations anymore.				Transition period needed to utilize formulas in various situations.

Table B.7: Responses for Interview Question 10

10. What are the practical changes that Introduction to Statistics teachers would need to undertake in order to enhance the use of web-based self-access Introduction to Statistics material of your students?			
Participant ID:	Topic 1: Instruction	Topic 2: Instructor Mastery	Topic 3: Mentoring
1 n/a			
2		Instructor mastery.	
3			Mentoring as opposed to lecturing.
4	Decide how much technology the teacher wants to include in his/her instruction.		

Table B.8: Responses for Interview Question 11

11. In your experiences what is the greatest pedagogical challenge in teaching students Introduction to Statistics?				
Participant	Topic 1: Different Math Backgrounds	Topic 2: Engaging Students	Topic 3: Instructor Mastery	Topic 4: Integration
1	Getting students of different math backgrounds up to speed so that everyone is at the same place.	Come up with math examples that relate to students' fields/areas of expertise to engage those that have mentally checked out.		
2			Instructors' mastery.	
3				Interrelationship of the different aspects of statistical analysis.
4 n/a				

Table B.9: Responses for Interview Question 12

12. In your experiences what are the greatest pedagogical opportunities in teaching Introduction to statistics to your students?		
Participant ID:	Topic 1: Sampling distribution	Topic 2: Real world connection
1		Connecting course content to real world scenarios.
2	Sampling distribution.	
3		Important to gear course material towards students' majors.
4		Very important to connect the classroom with real world.

Table B.10: Responses for Interview Question 13

13. In your experiences what is the greatest practical challenge in teaching Introduction to statistics to your students?						
Participant	Topic 1: Information	Topic 2: Fundamental Skills	Topic 3: Relevance	Topic 4: Technology	Topic 5: School Budget	Topic 6: Expectations
1	Finding information that is relevant to the course when there is a lot of broad/general information to sort through.		Finding a connection between course material and students' fields/areas of interest.			
2				Access to technology.	Monetary problems in the schools.	
3	Too much information to cover in one semester.	Reading skills.				Not meeting student expectations of what is required to grasp material.
4	Focus on relevant information in a world of abundant information.	Understanding concepts - being able to tell students when they can use a particular concept would be a huge accomplishment.				

Table B.11: Responses for Interview Question 14

14. What are the Best Practices of your colleagues when teaching Introduction to Statistics to undergraduate students?			
Participant ID:	Topic 1: Customized Instruction	Topic 2: Balanced Curriculum	Topic 3: Active Learning
1	Differentiating Instruction to meet students' needs.		
2		Balanced curriculum.	
3 n/a			
4			Providing active learning opportunities.